MESON: Cross-Slice Communication at the Network Edge

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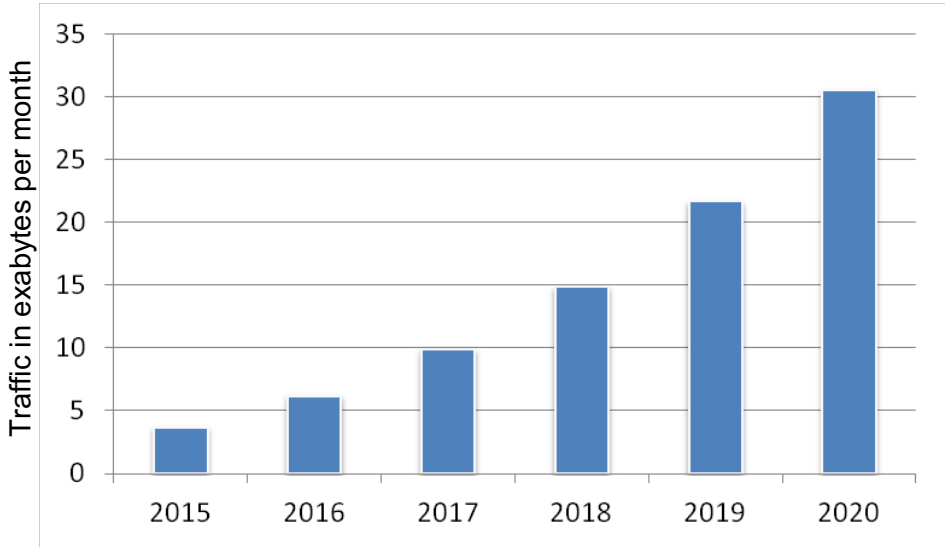
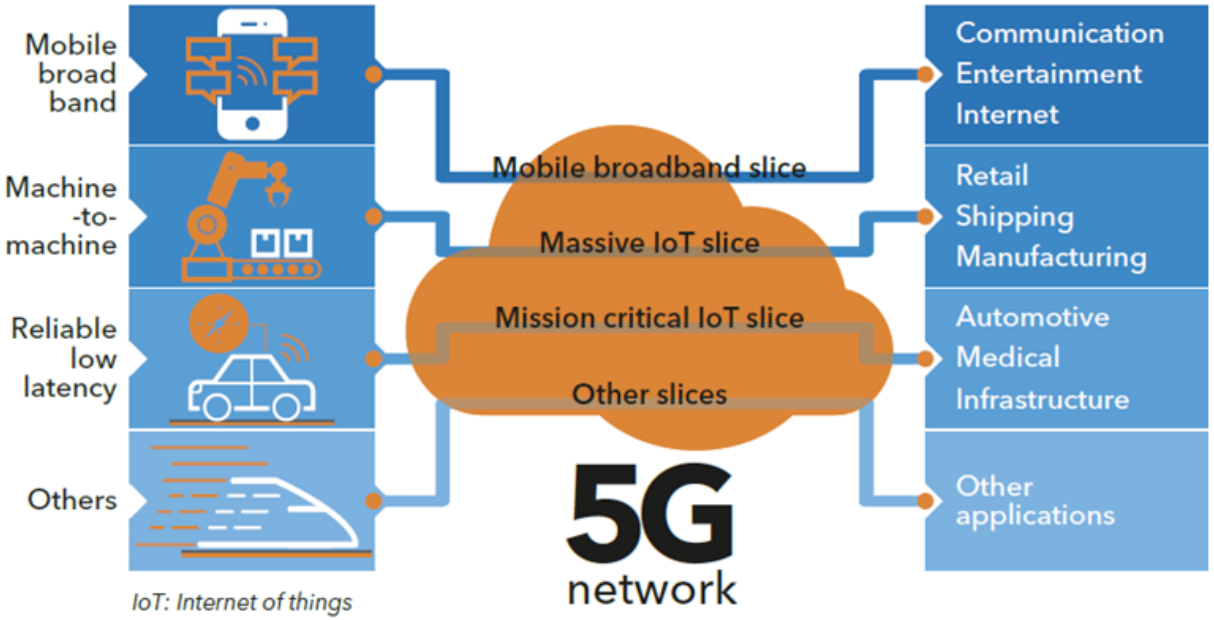
Introduction

- Increasing stress on data networks:
  - Large traffic volumes
    - Mobile data traffic is expected to grow to 30.6 exabytes per month by 2020 [Cisco]
    - More than 100% increase in the control plane traffic per year [Juniper]
  - Application diversity
    - Mobile broadband
    - Voice
    - IoT / M2M
    - Mission-critical IoT



Network Slicing

- Network slicing as a key ingredient in 5G:
  - Multi-service:
    - Service-tailored slices
  - Multi-tenancy:
    - Slices leased to tenants



Source: ITUNews

Network Slicing Enablers

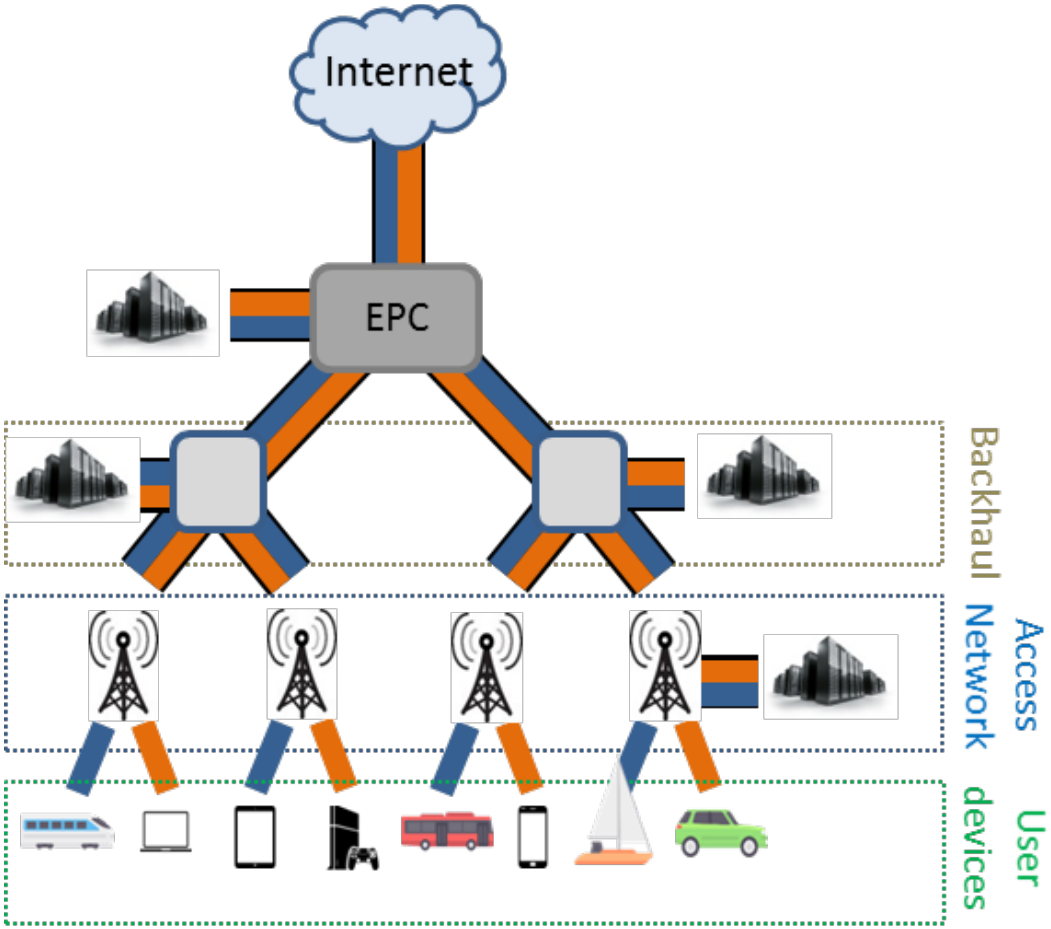
- Network Function Virtualization (NFV)
  - Processing elements, e.g., FW, NAT, proxy, cache
  - LTE elements, e.g., gateways, MME
  - Other service elements, e.g., object identification

- Software Defined Networking (SDN)
  - Service chaining
  - Example: Augmented reality (AR) service
    - Object detection (OD)
    - Feature extraction (FE)
    - Object recognition (OR)

Cross-Slice Communication

Edge Computing

- Computation and storage proximate to client devices
  - Micro-datacenters at the edge
  - Computing and storage available in BS and Wi-Fi APs
- Significant benefits for latency-sensitive services
  - Location-based services
  - Augmented reality (AR)
- Great opportunity for network slicing

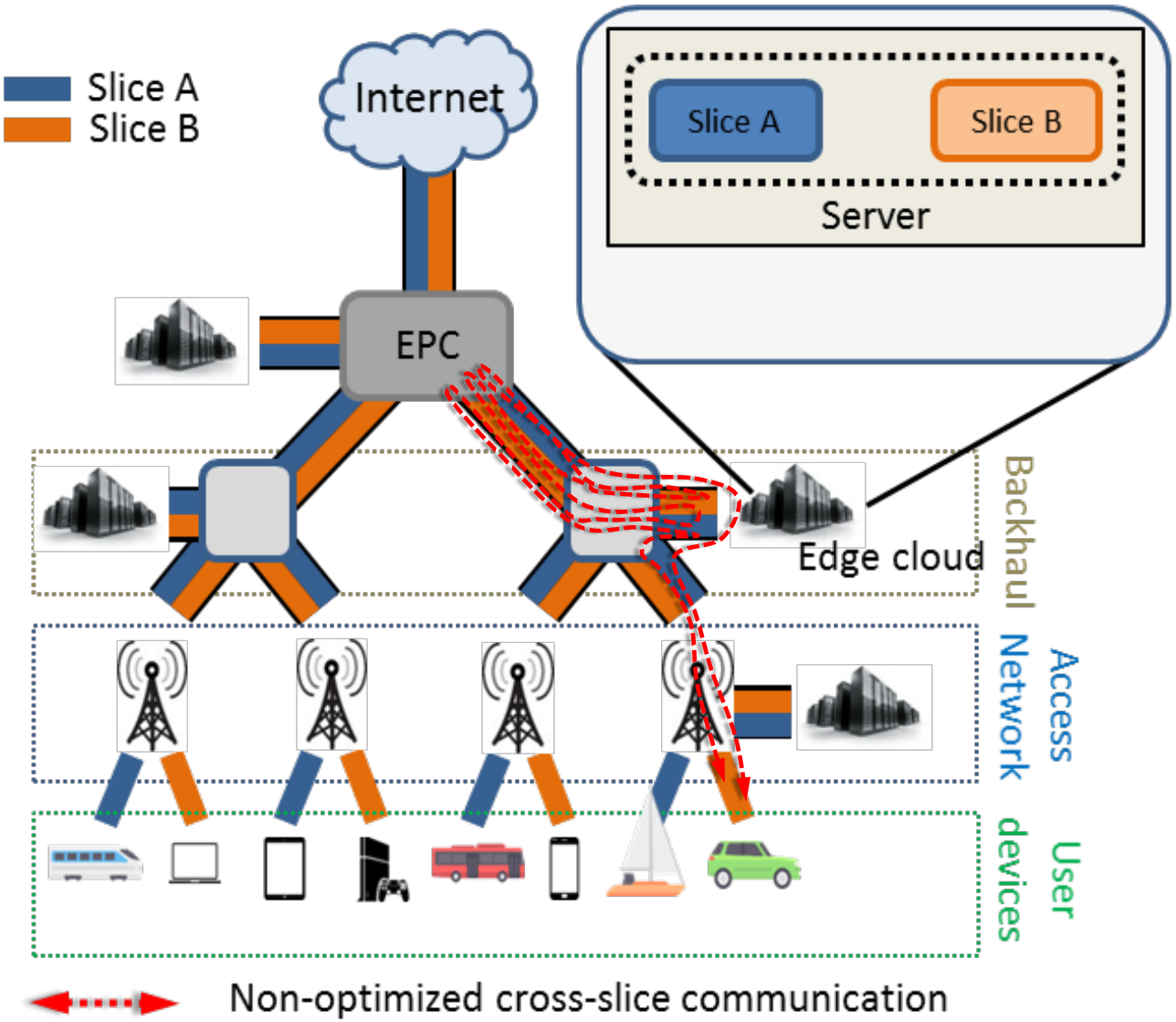


Limitations

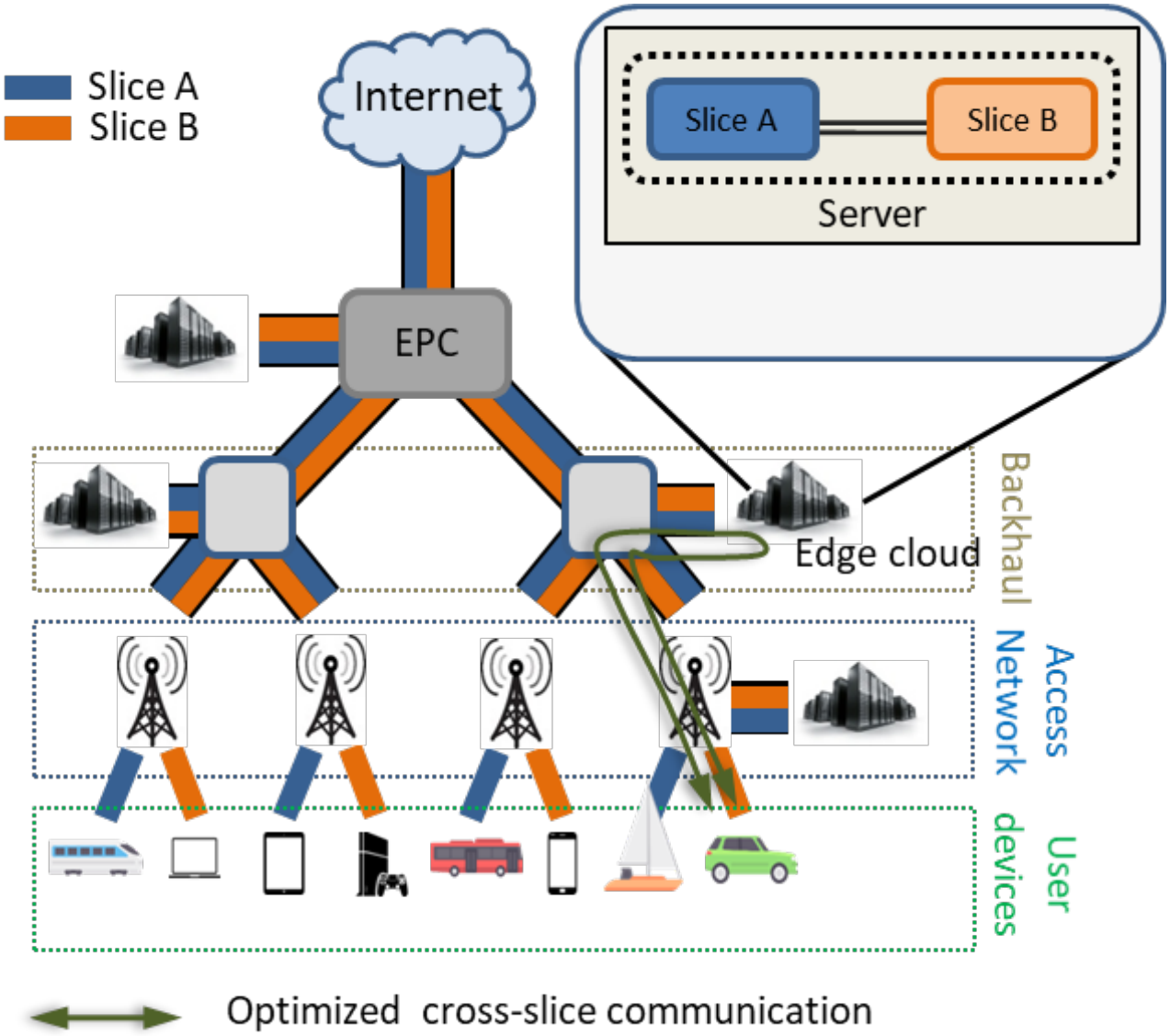
- Service ecosystem requires cross-service interactions:
  - Augmented reality (AR)
  - Social media
  - Advertising
  - Industry 4.0 (e.g., Robotics)

- Network slices are strictly isolated:
  - Sub-optimal cross-slice communication
    - Communication path via the (mobile) core network

Non-Optimized Cross-Slice Communication



Optimized Cross-Slice Communication



Optimized Cross-Slice Communication

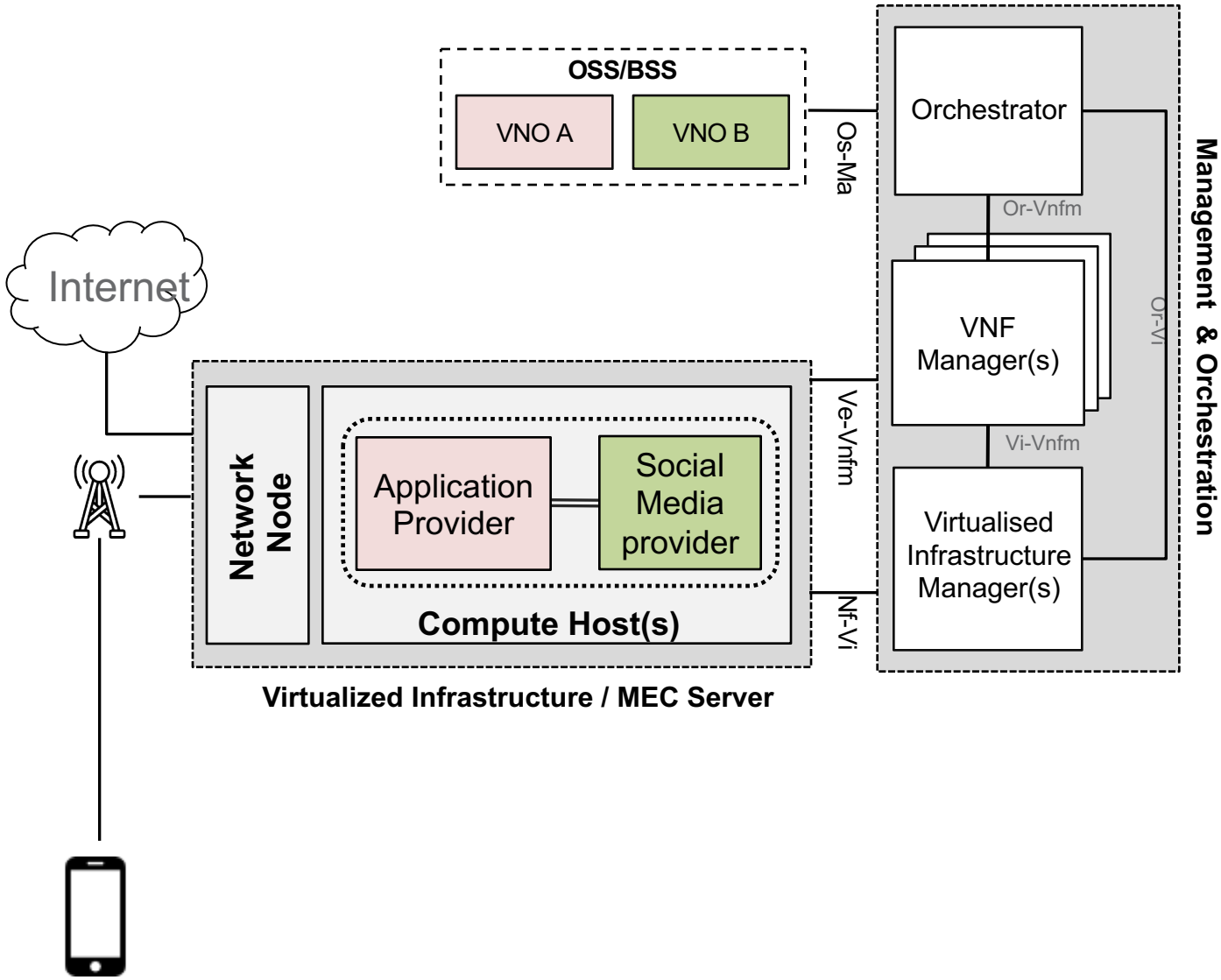
- Benefits:
  - Reduction in backhaul/transport traffic
  - Reduced latency

- Use cases:
  - Symmetric communication:
    - Cache peering
  - Asymmetric communication:
    - AR / social media
    - Human-robot collaboration (Industry 4.0)

AR/Social Media Use Case

- AR slice with touristic / city guide:
  - Live feed upload from mobile phone camera
  - Overlaid metadata for current location
    - Road names
    - Nearby landmarks/sights
    - Navigation
- Social media slice:
  - Personalized recommendations
  - Social events

AR/Social Media Use Case



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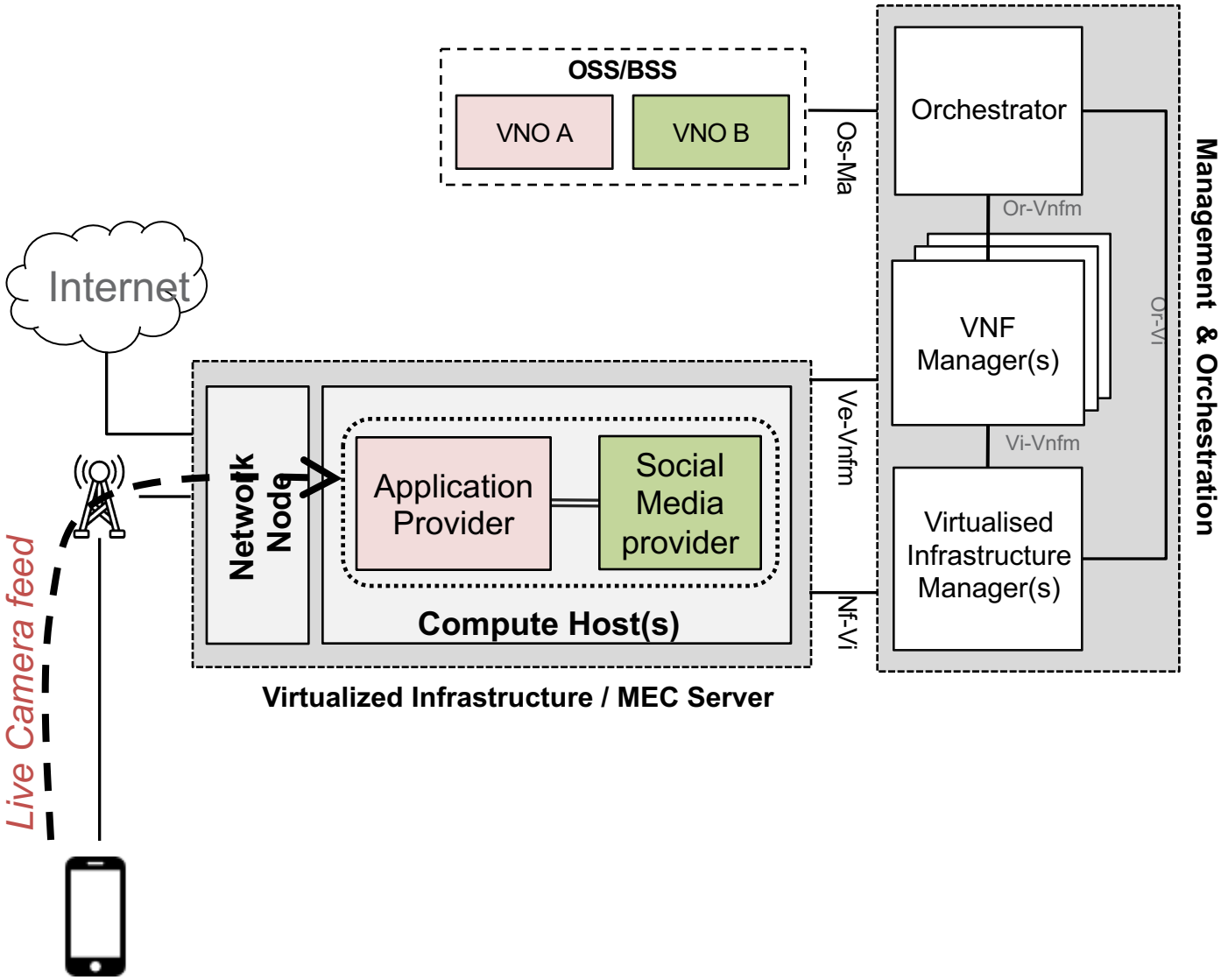

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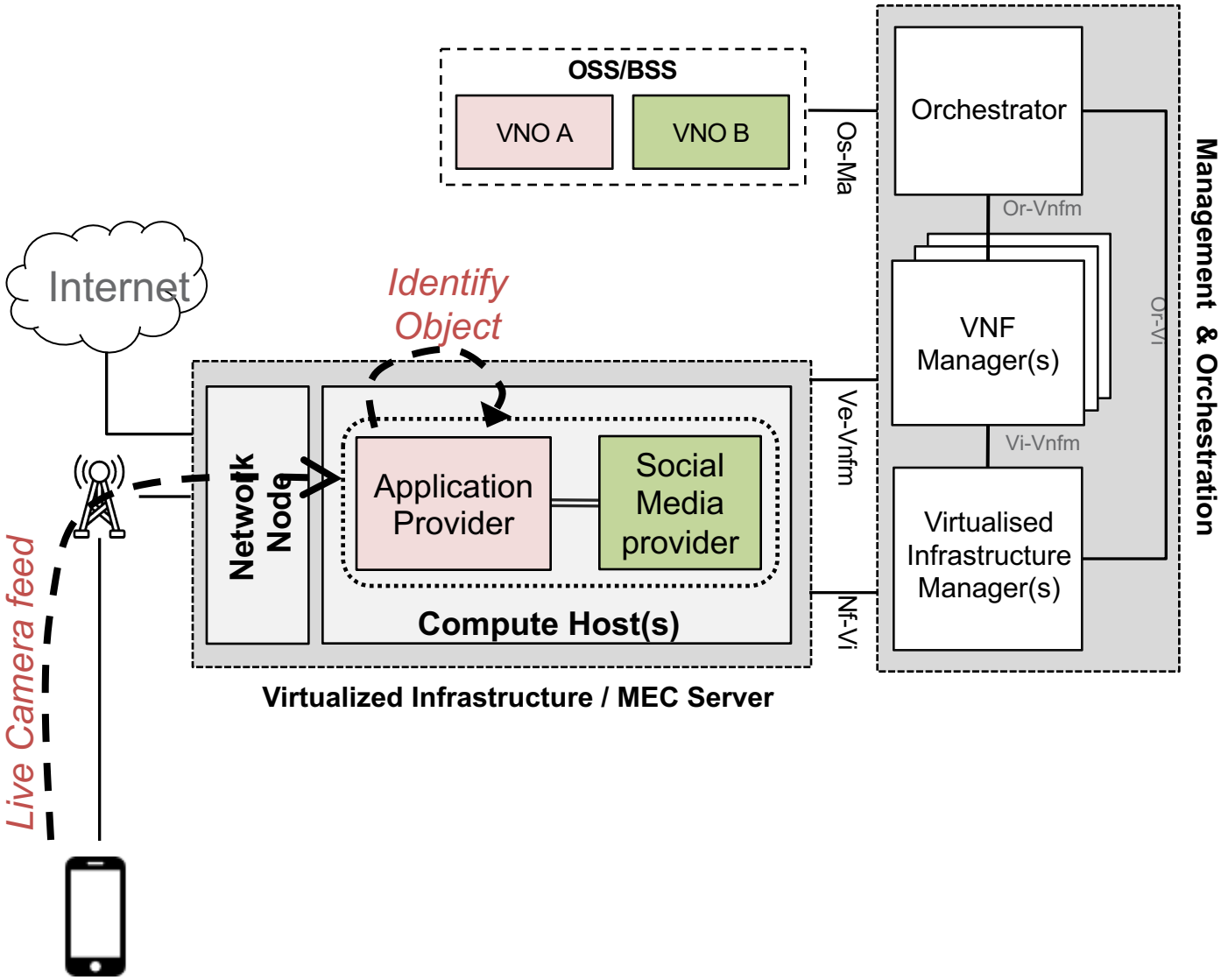

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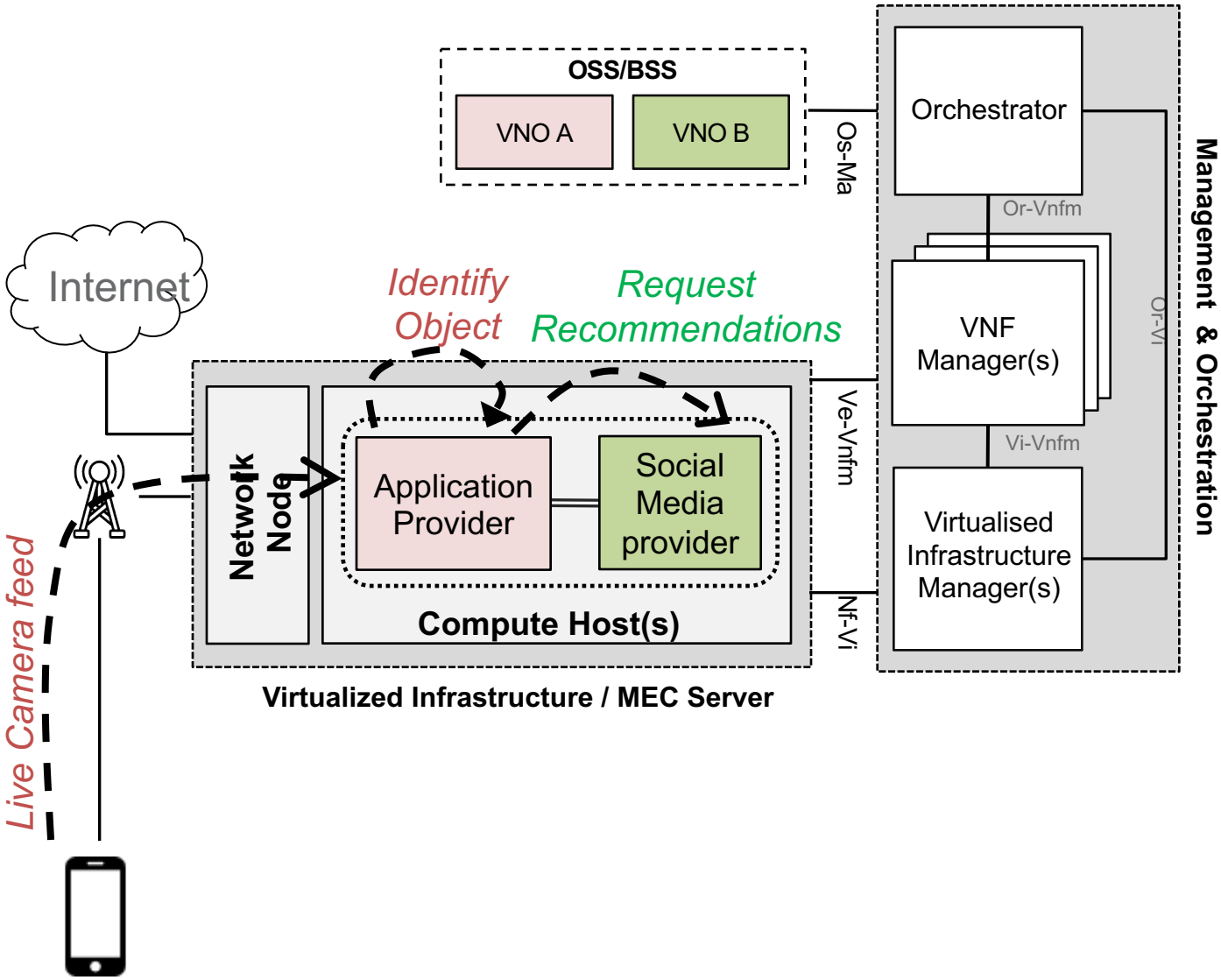

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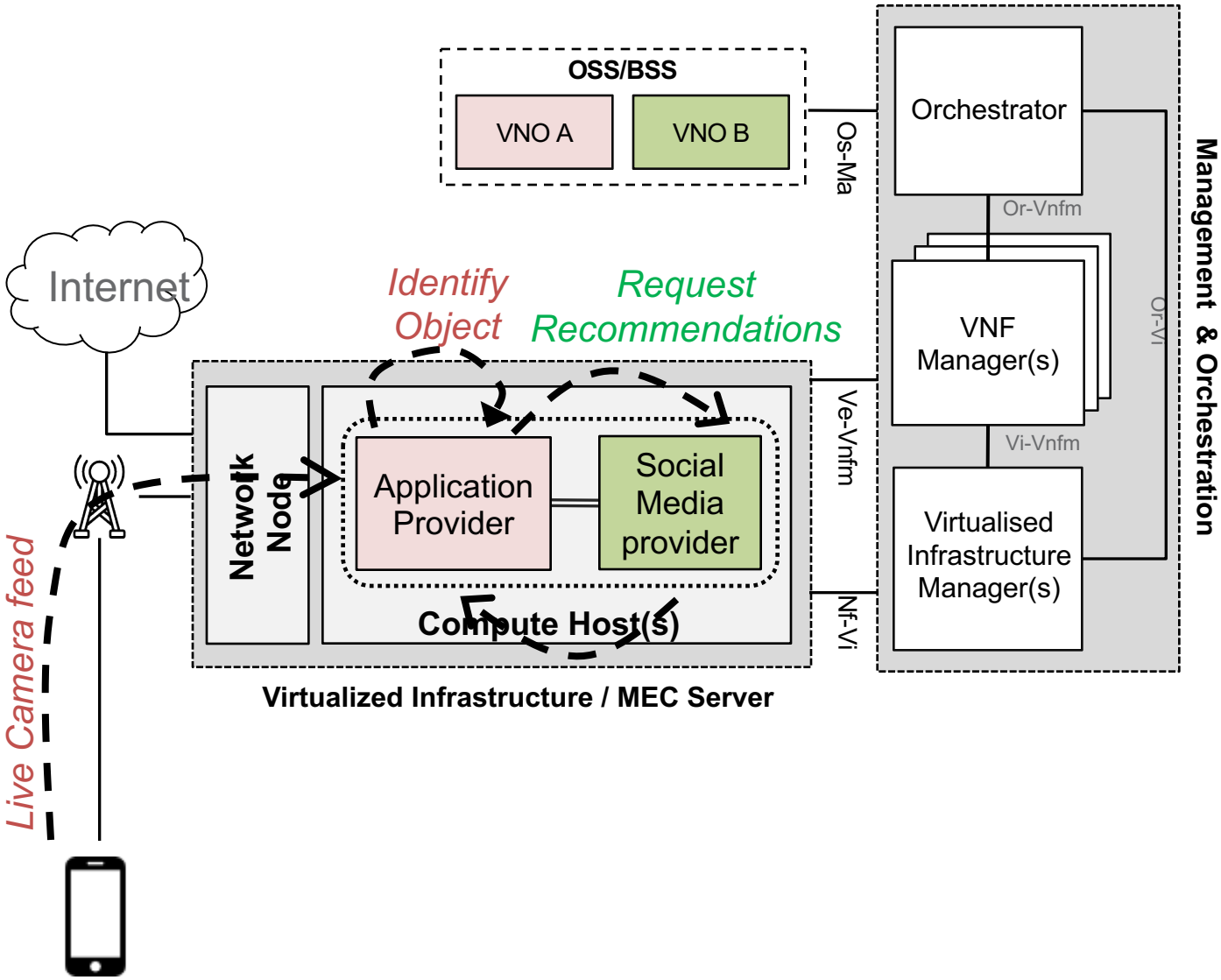

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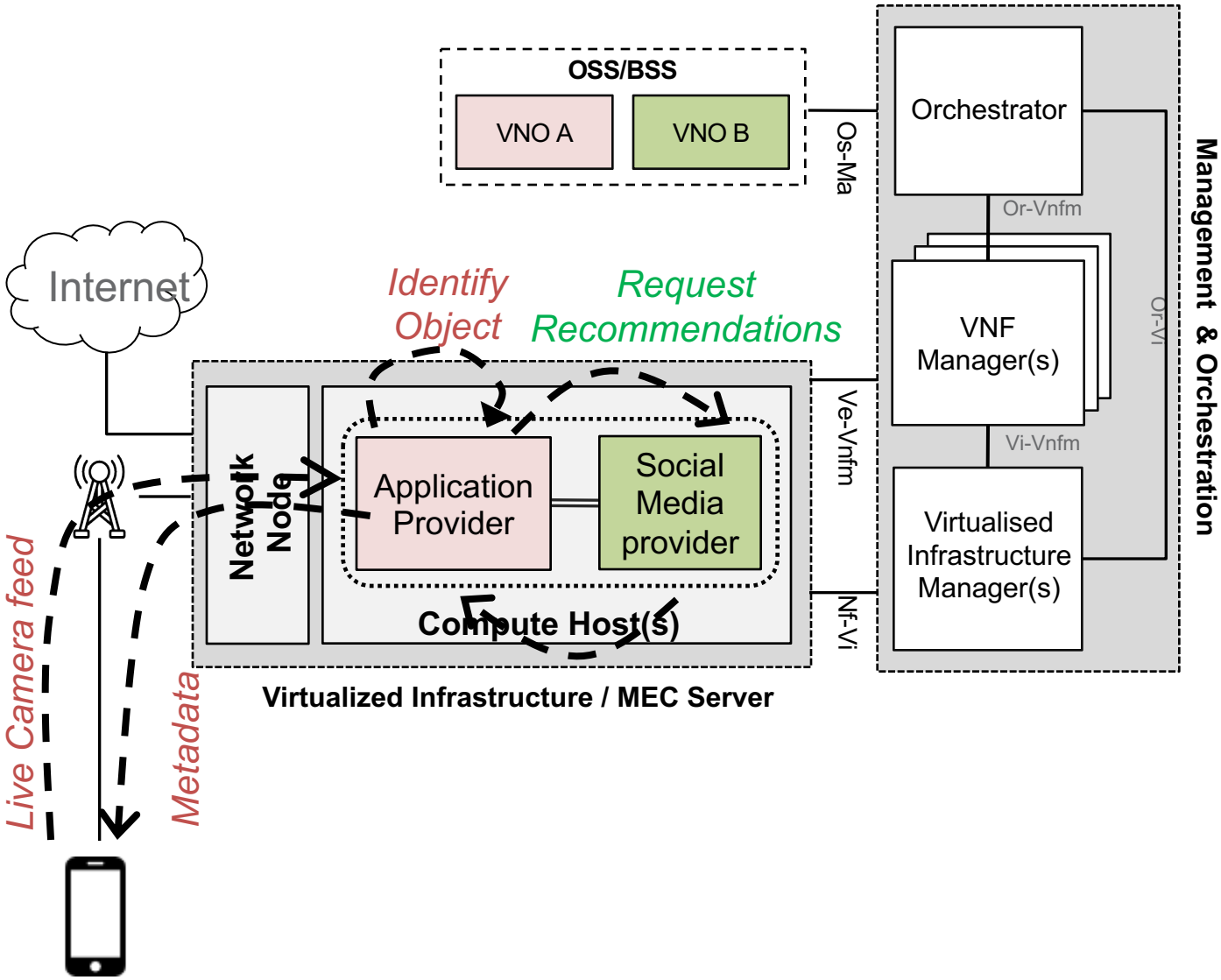
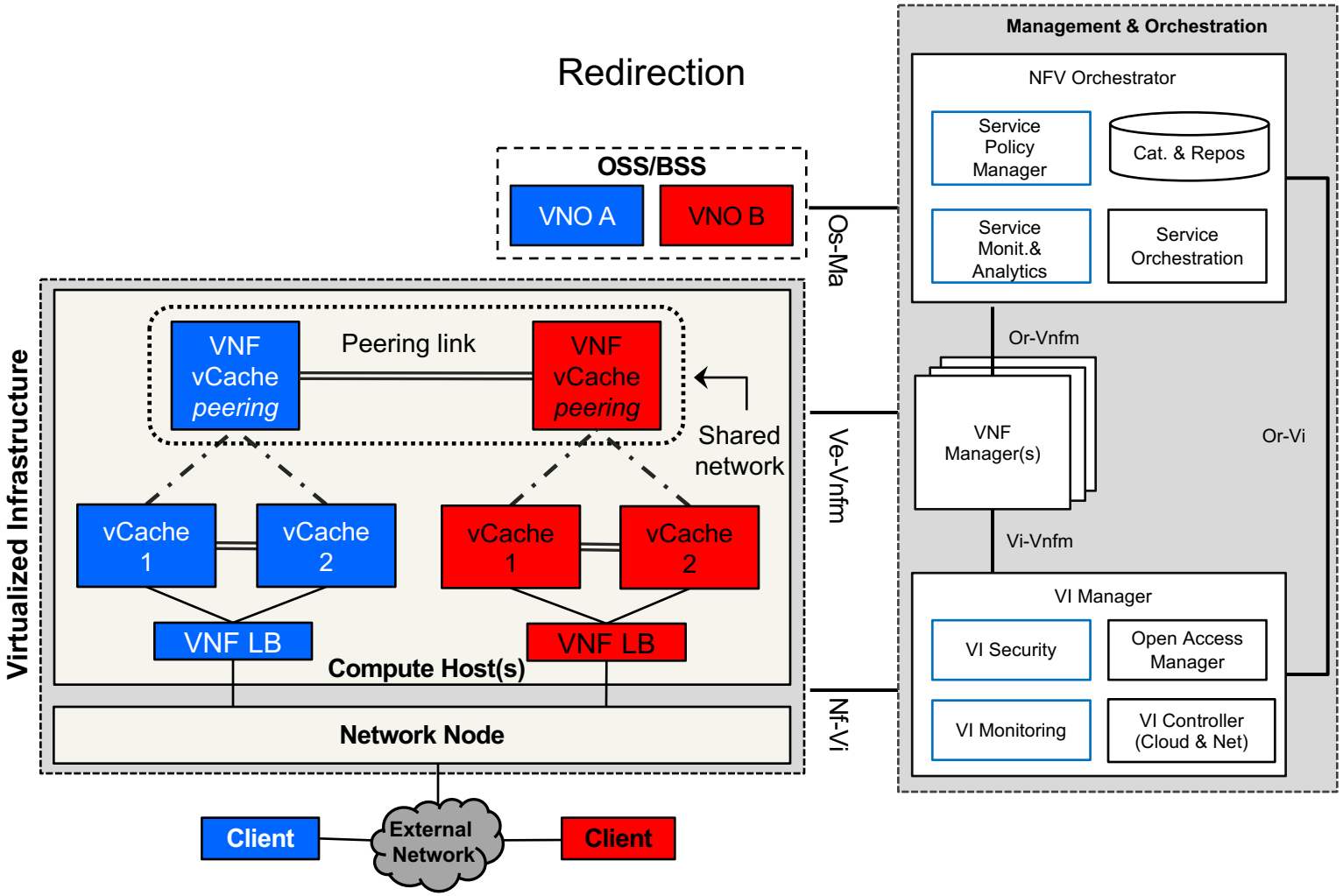


Cache Peering Use Case

- Virtual CDNs deployed in separate co-located slices:
  - Opportunity for VNO synergy:
    - Request redirected to other VNO (operating a co-located vCDN), in case of cache miss
    - Lower latency, in case content is located and fetched from the other VNO

Cache Peering Use Case



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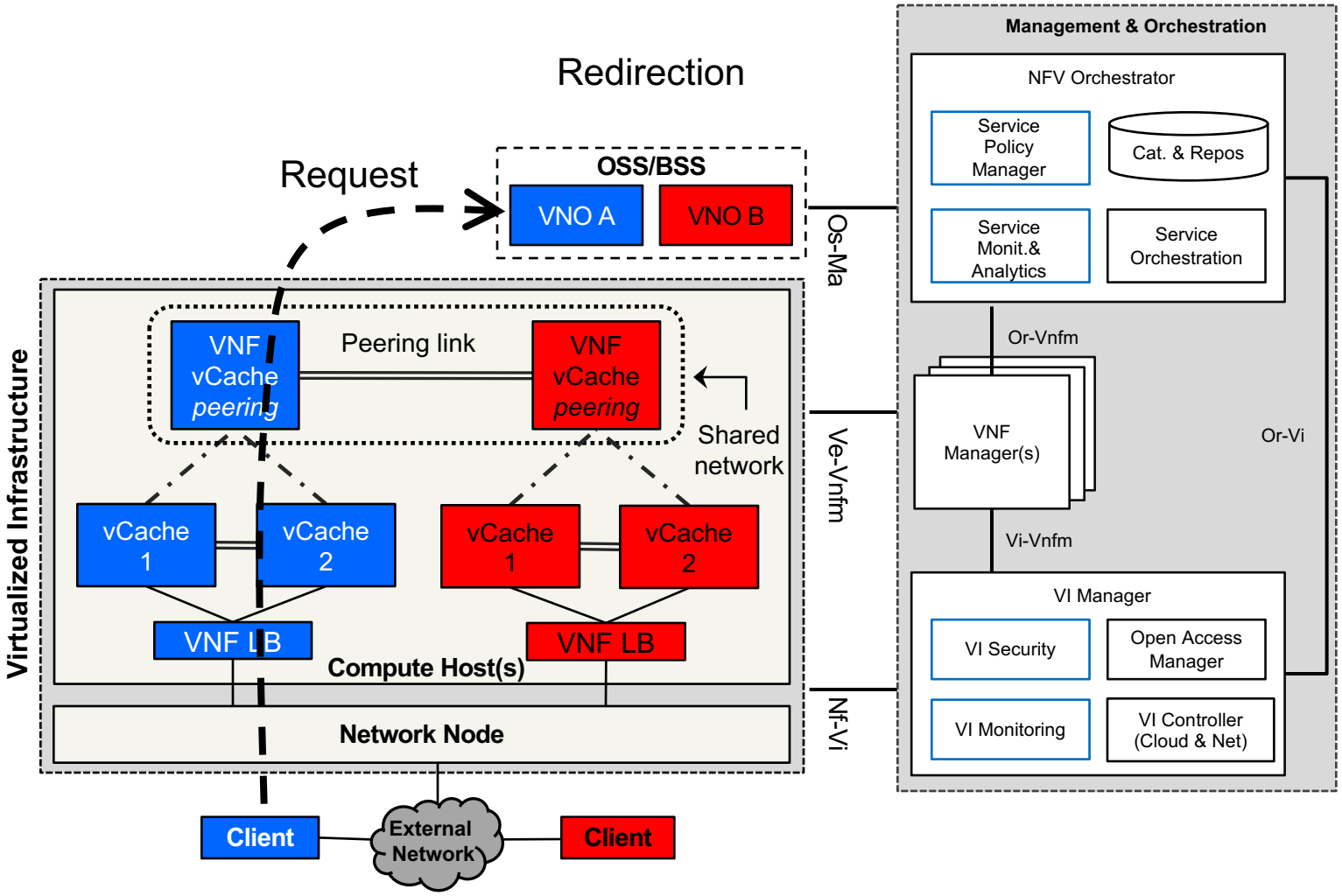

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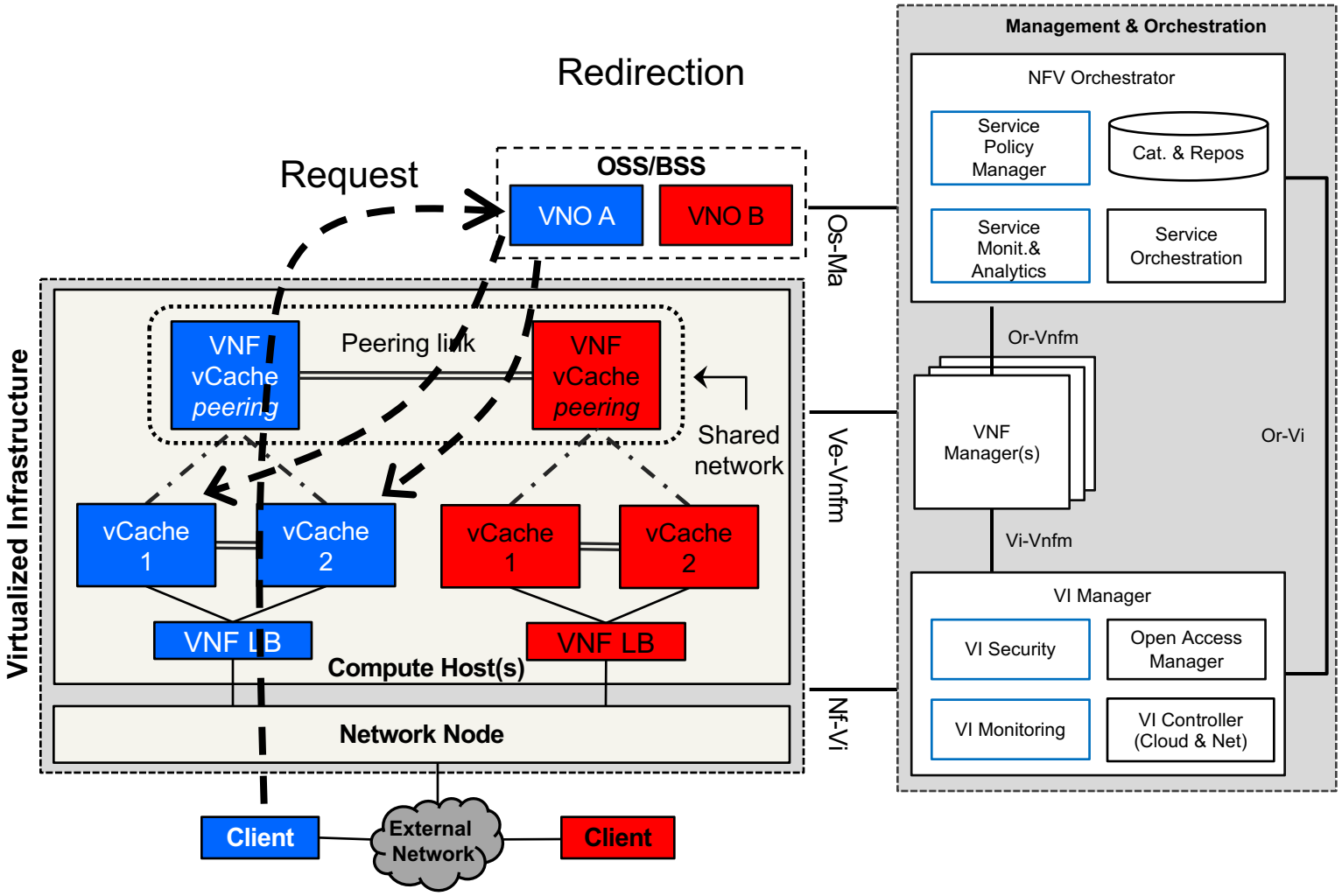

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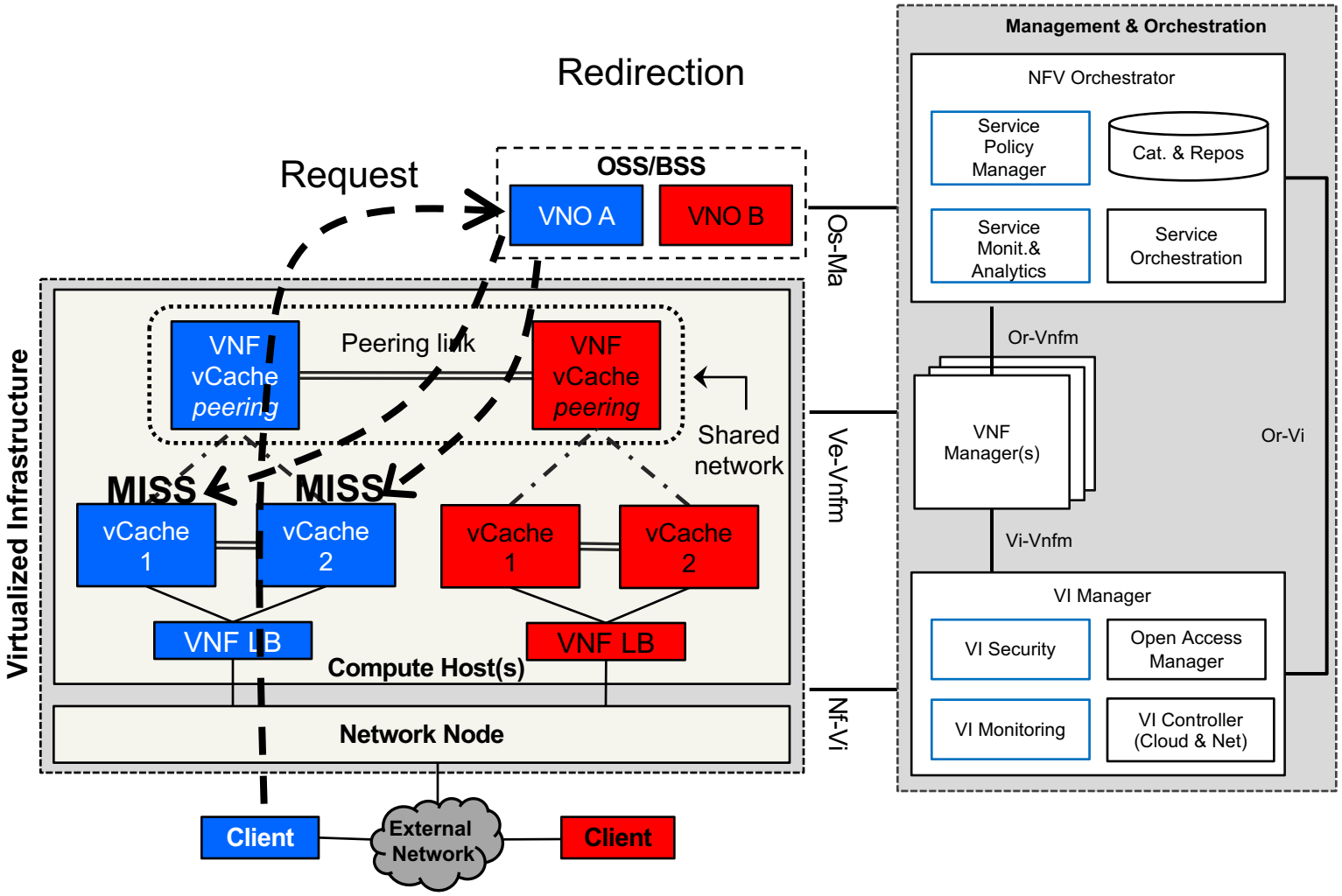

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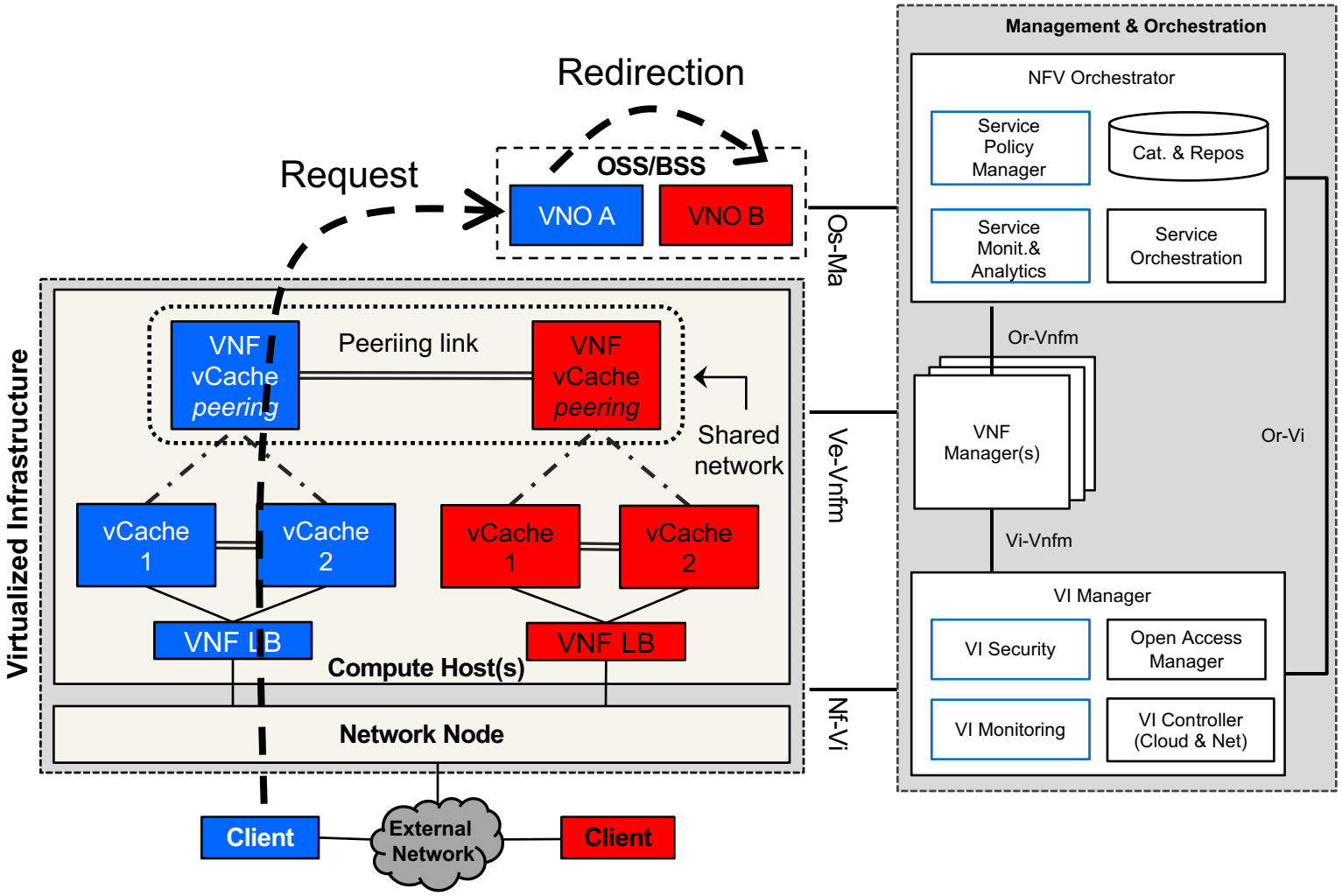

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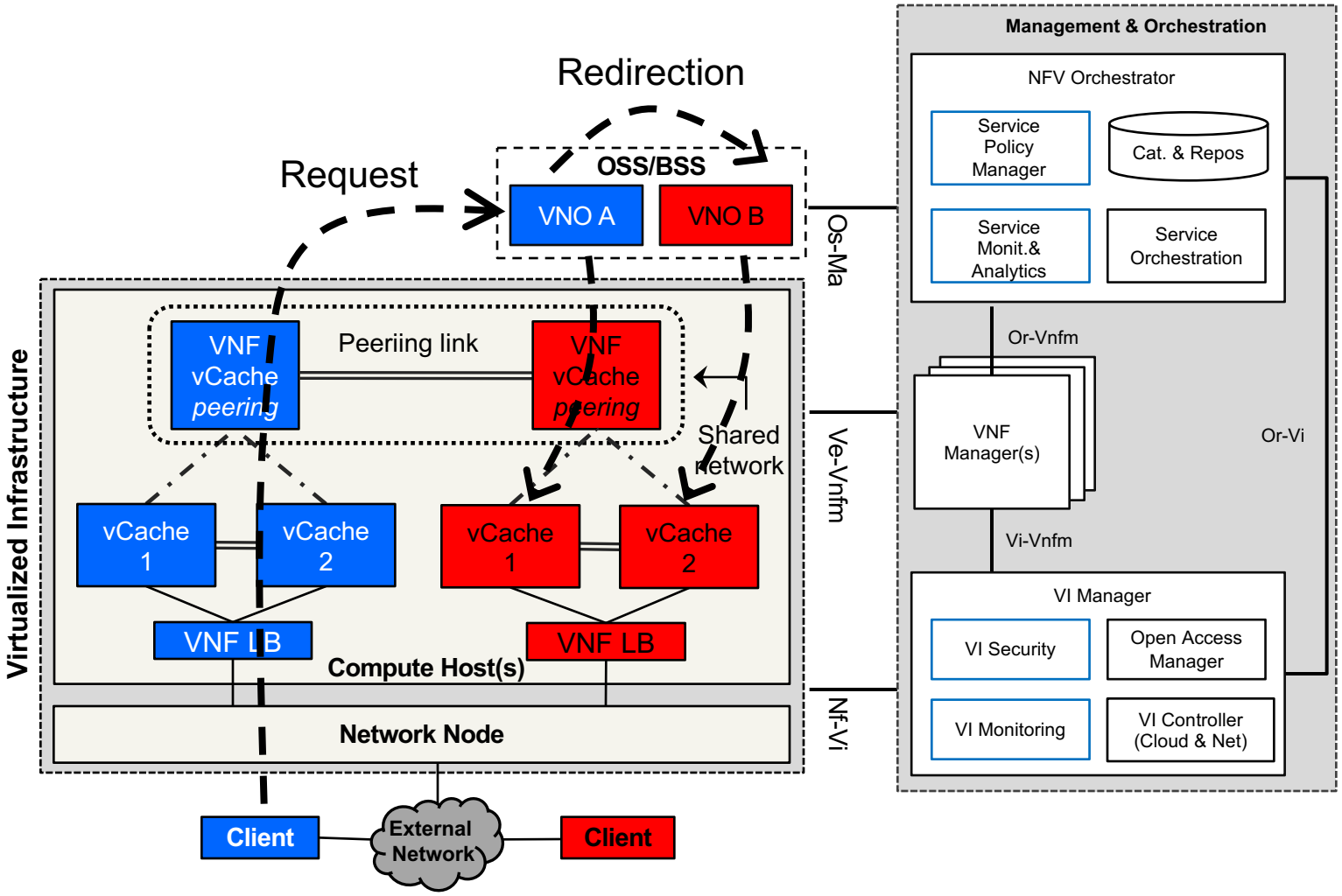

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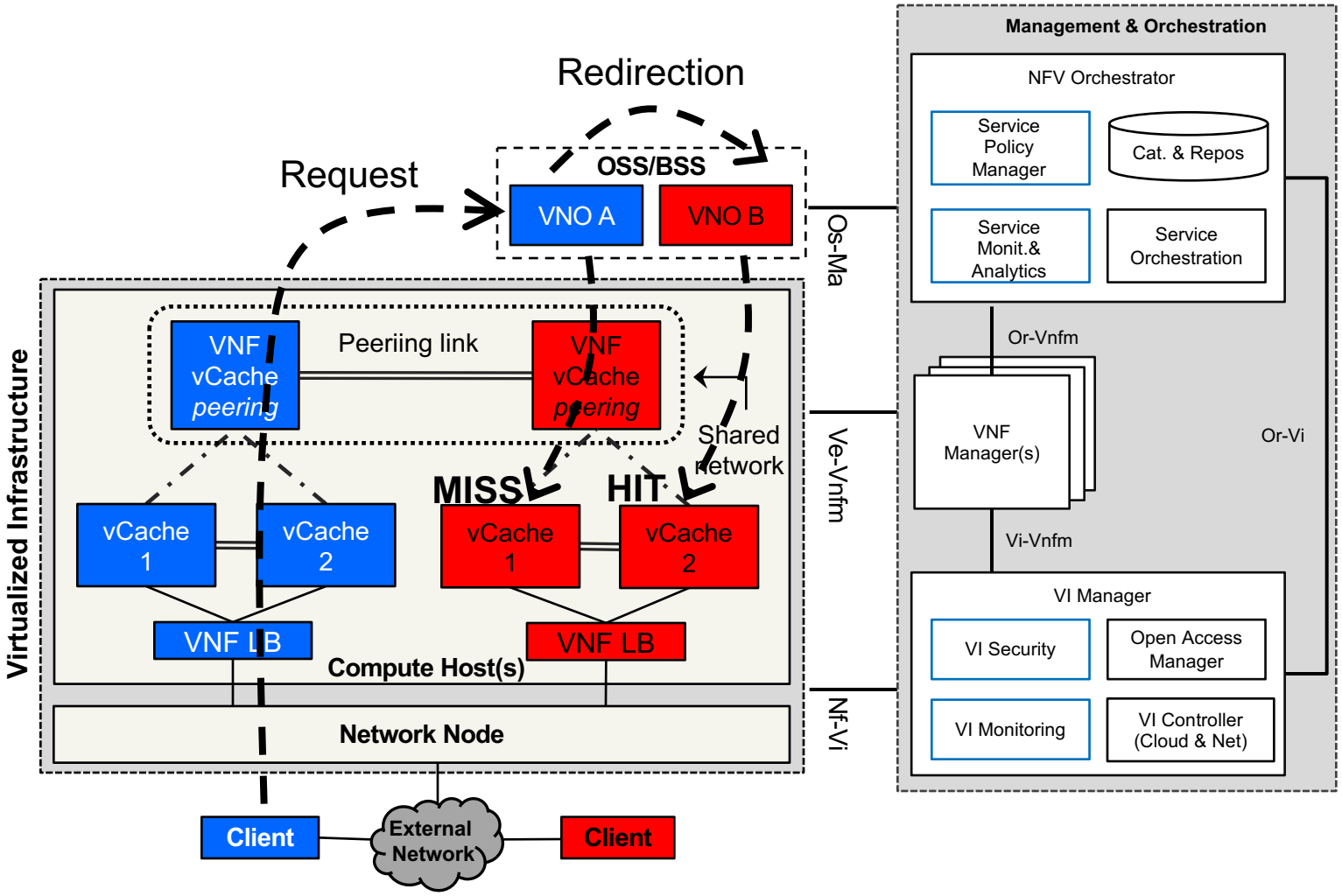

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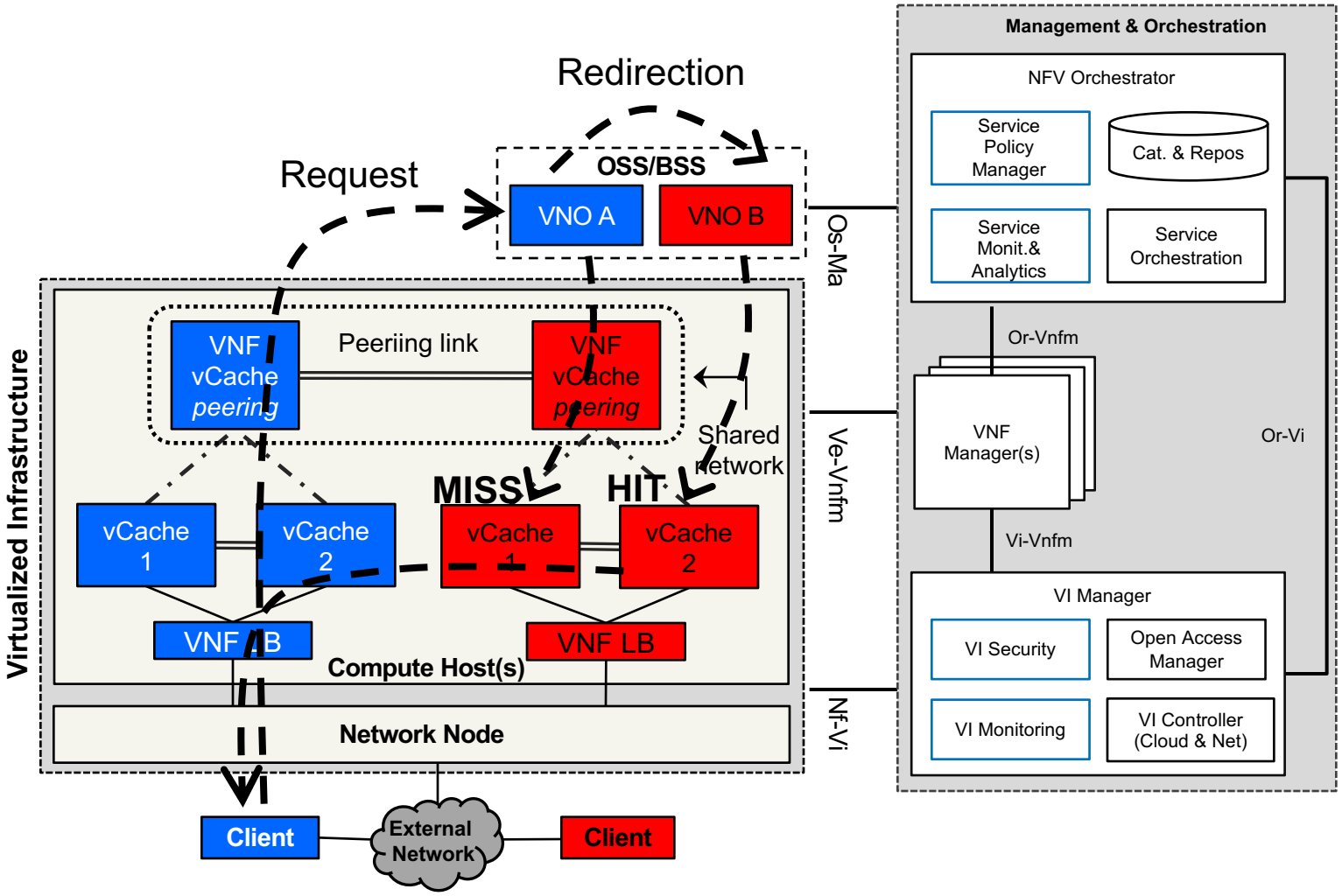
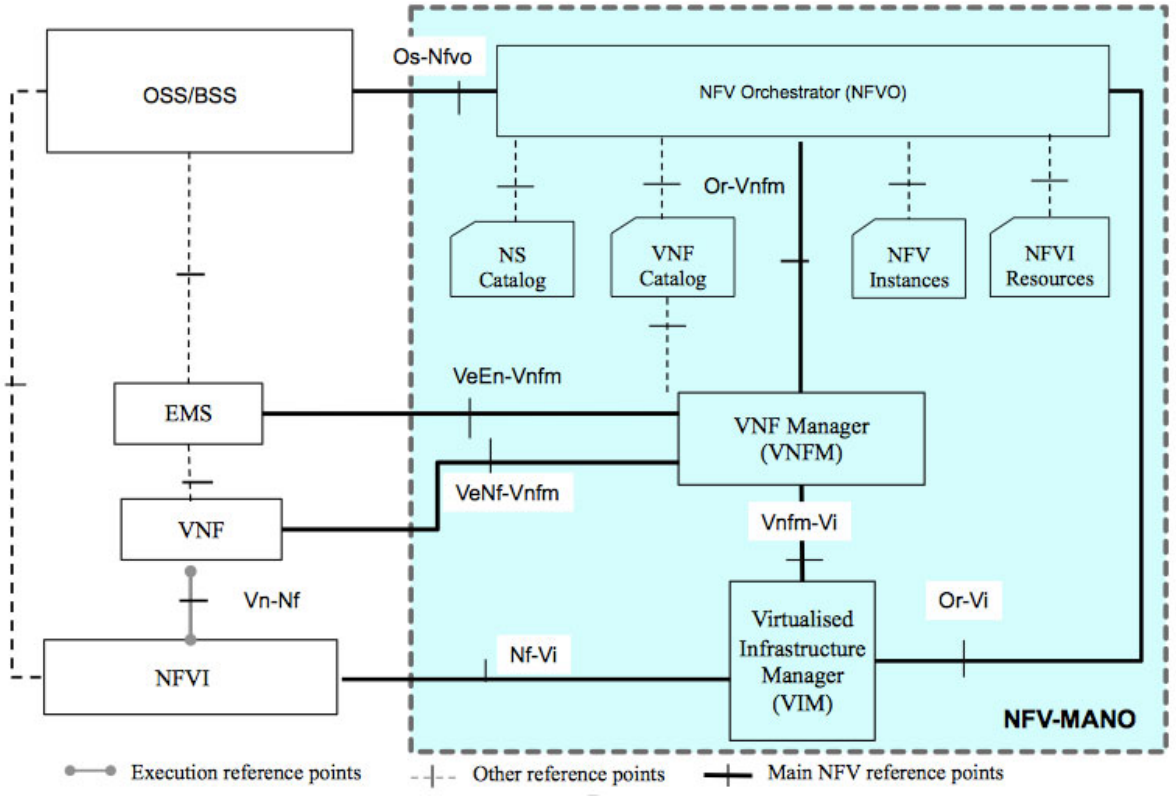


CSC Orchestration Requirements

- Service discovery:
  - Announcement of cross-slice communication service (CSC) offerings
  - Expression of interest for CSC
- CSC establishment:
  - Discovery of optimized CSC path
    - Potential joint optimization with slice placement
  - CSC path setup
- Policy enforcement and control:
  - Traffic inspection and monitoring
  - Auto-scaling
  - Billing / accounting

CSC Orchestration Approach

- Enhanced MANO framework for optimized and secure CSC and slice tenant interactions



Source: ETSI NFV MANO

Service Discovery

Service Descriptors

AppD	Data Type
appID	String
appName	String
appProvider	String
…	…
swImageDescriptor	SwImageDescriptor
…	…
appServiceRequired /Optional	ServiceDependency
appServiceProduced	ServiceDescriptor

ServiceDescriptor	Data Type
serName	
…	…
transportsSupported	Structured (inline)
peerPolicy	***PeerPolicy***

ServiceDependency	Data Type
serName	
…	…
serTransportsSupported	Structured (inline)
requestedPermissions	Not Specified
depProfile	DependencyProfile

PeerPolicy	Data Type
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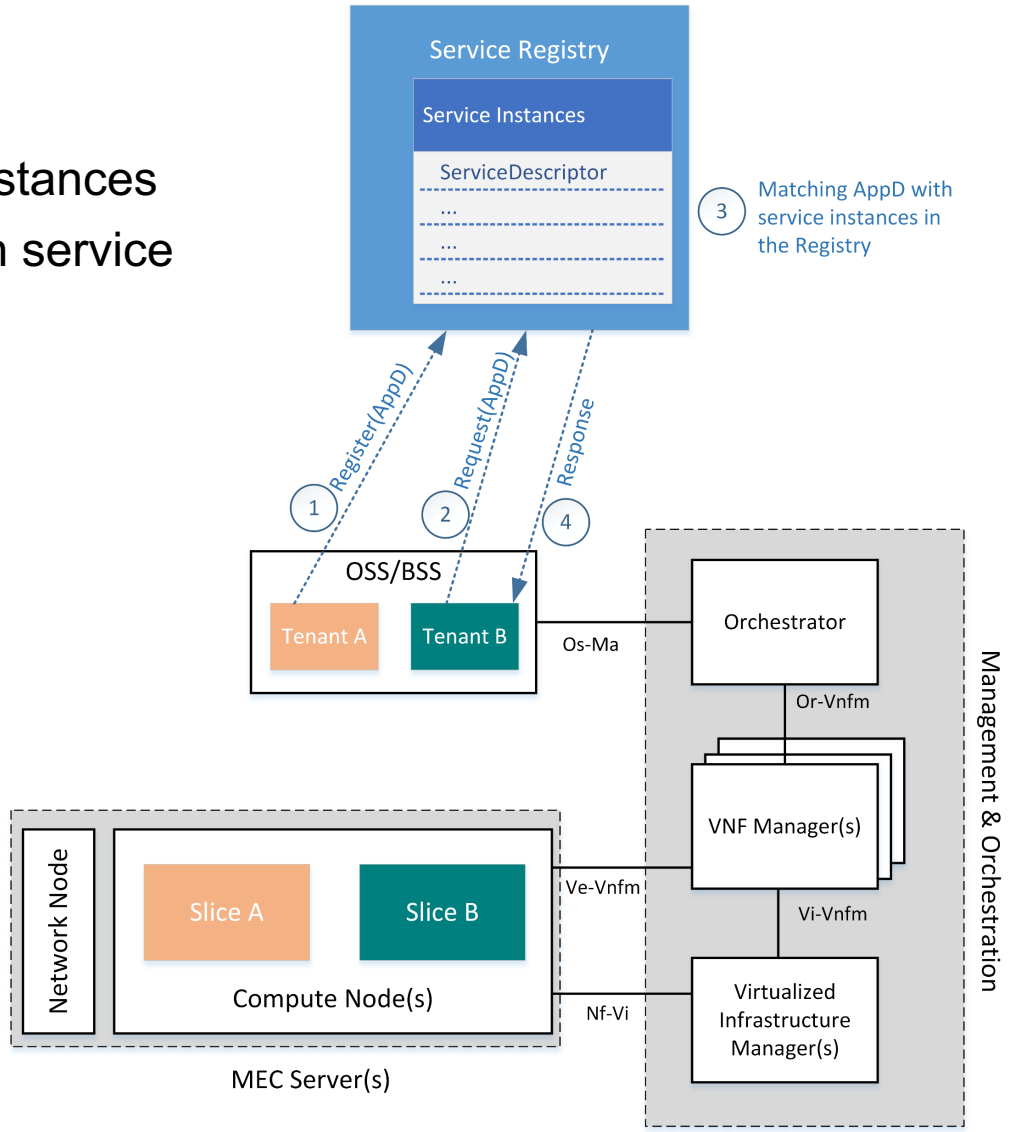
Service Discovery

- Service Registry:
  - Registration of service instances
  - Matching of interests with service instances



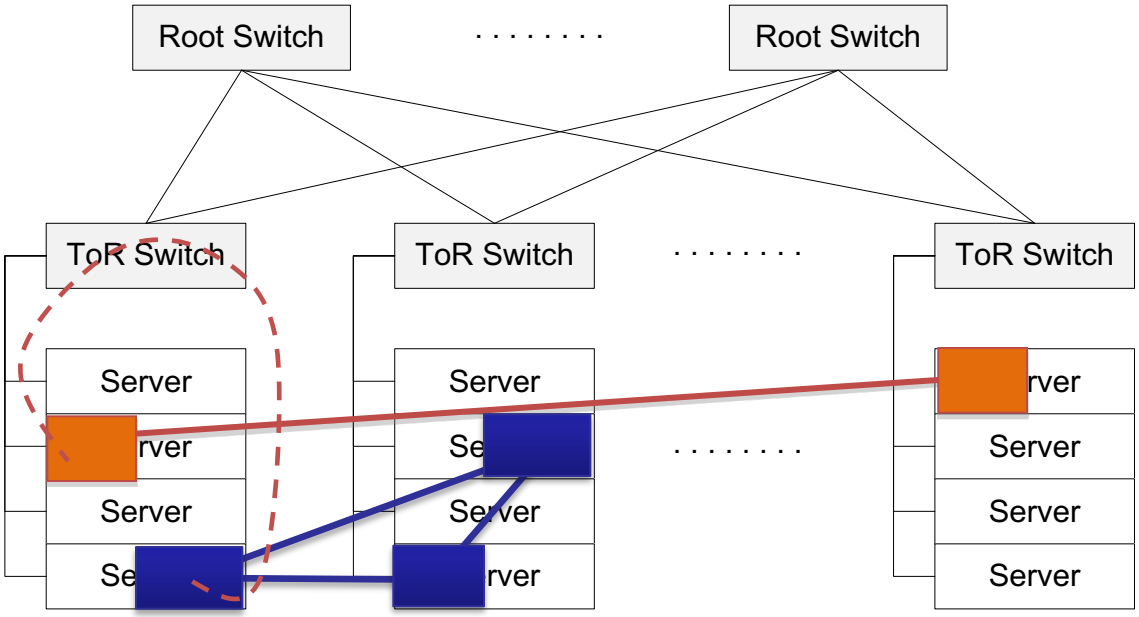
Service Discovery

- Single PoP:
  - Consumer expresses interest for communication with co-located services
  - Service Registry returns all matched service instances within the PoP
- Multi-PoP:
  - Consumer supplies CSC interest before slice deployment
  - Service Registry returns all PoPs with matched service instances
  - The most suitable PoP has to be selected for consumer's slice deployment
    - Method for PoP ranking

Cross-Slice Communication Establishment

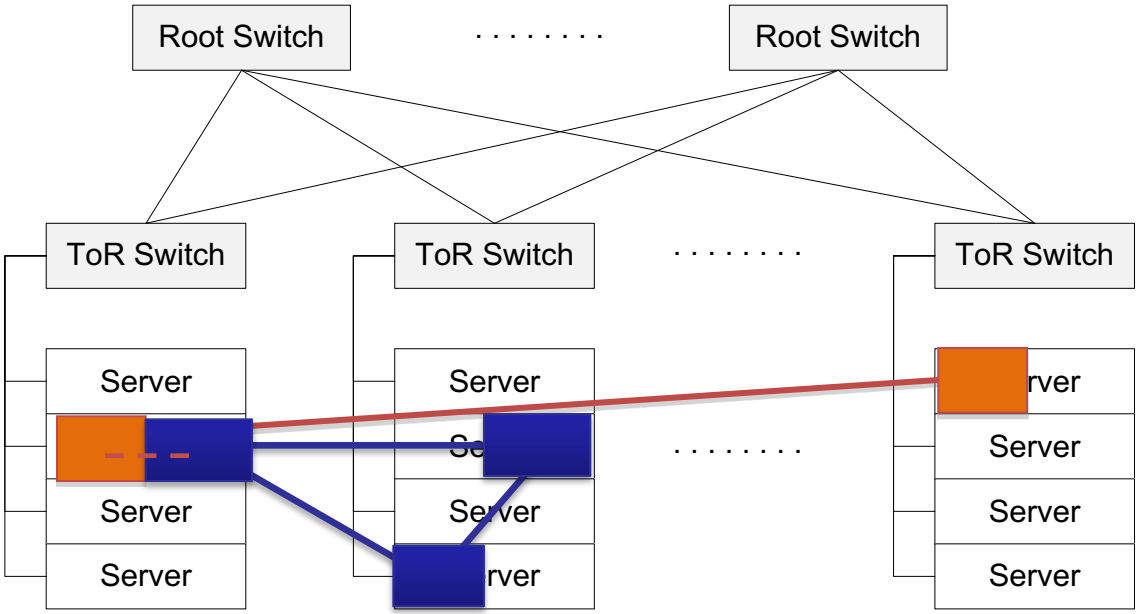
Path Assignment

- Both slices are co-located on the same edge cloud
- Path assignment based on BW demands and topology constraints
  - e.g., selection of shortest path with BW guarantees



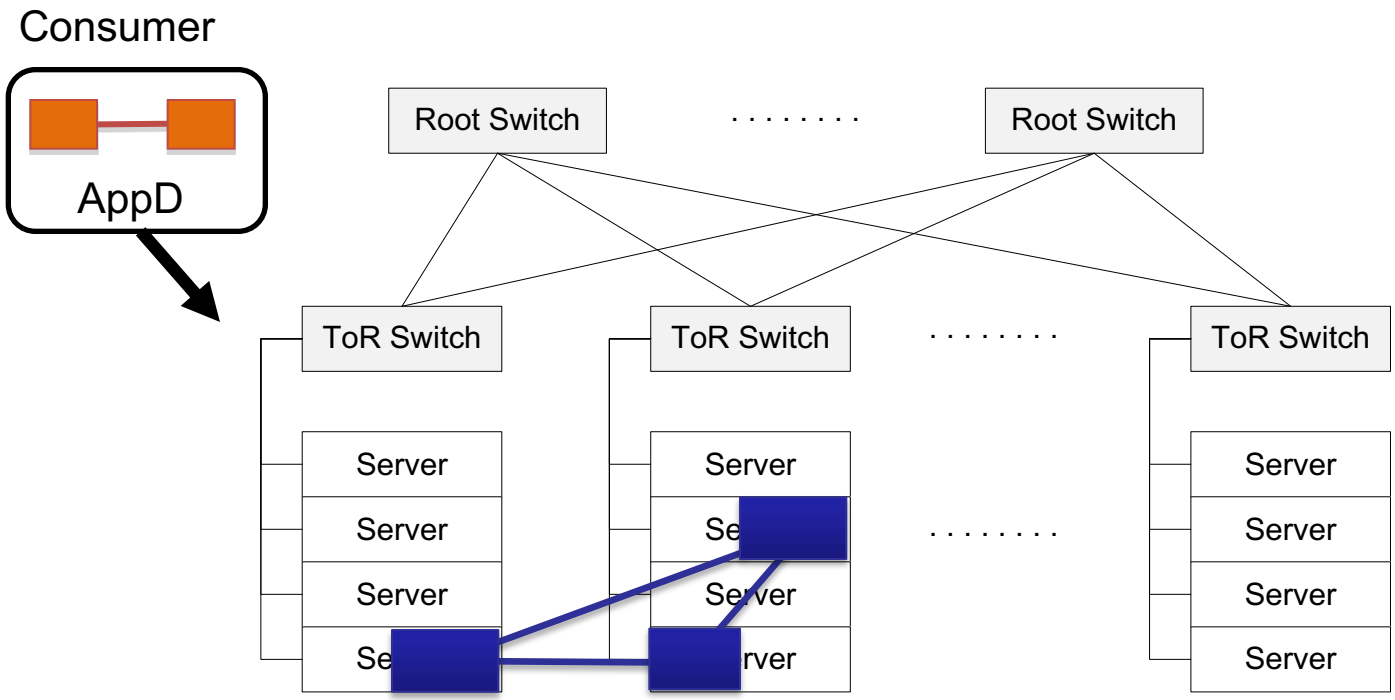
Path Assignment

- Possible resource migration for enhanced slice co-location
  - e.g., migration of slice element (e.g., VNF) to the same server
    - Traffic steering via OpenvSwitch



CSC-Aware Slice Placement

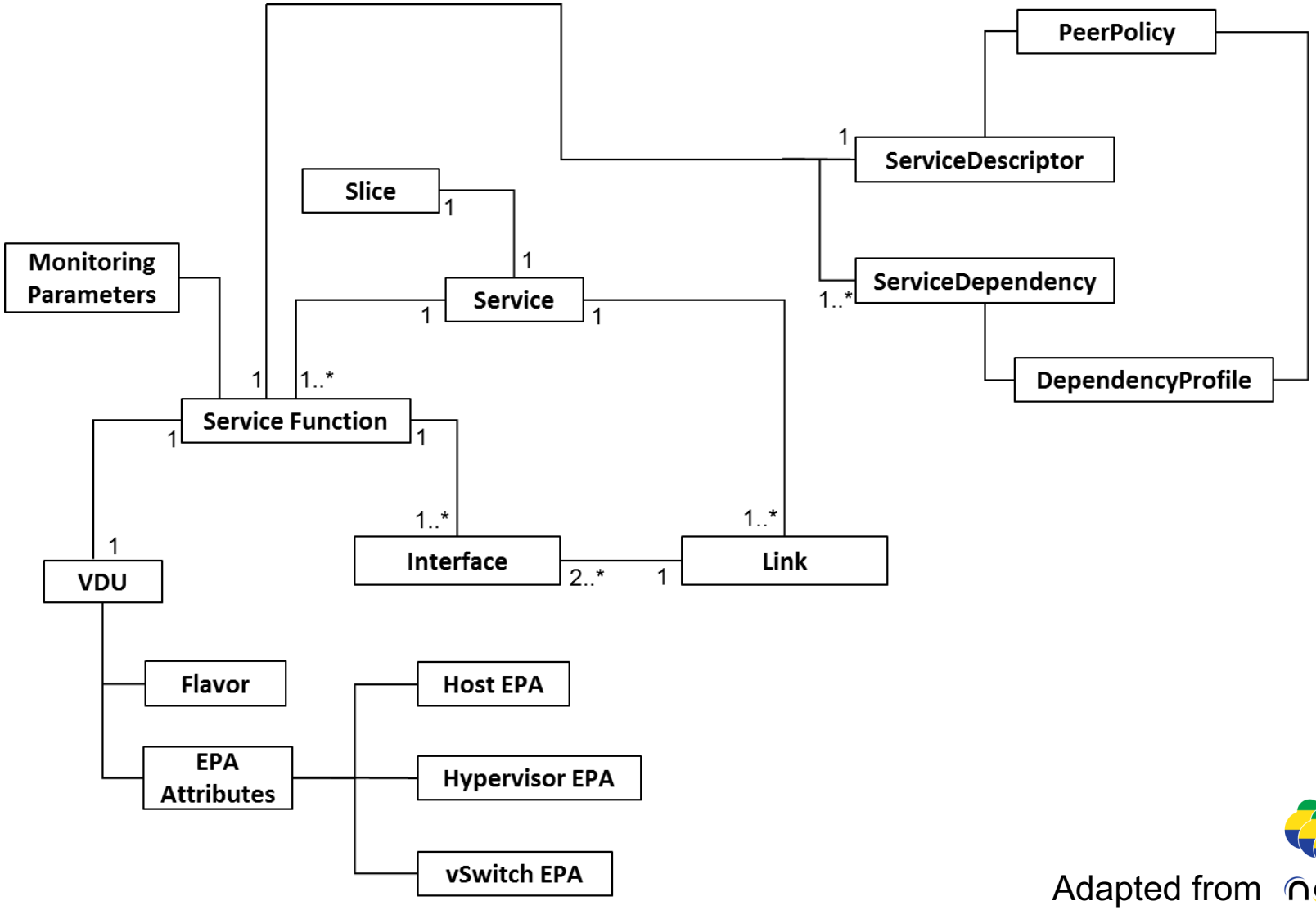
- Consumer supplies slice specification with CSC interest
- Candidate PoPs retrieved from Service Registry
- Path assignment jointly optimized with slice placement
  - Optimization based on slice resource/topology demands and CSC



Slice Model

- Slice specification:
  - Properties and requirements should be addressed by the information model
    - Connectivity graph
    - Resource constraints (CPU, memory, BW, etc)
    - Performance KPIs (requires translation to resource demands)
    - Other constraints (e.g., geo-location of slice nodes)

Slice Model



Adapted from necos

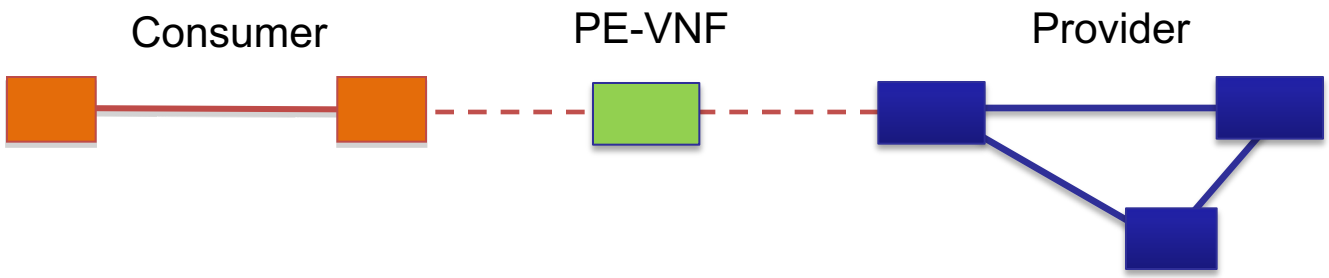
Cross-Slice Communication Policy

CSC Policy and Control

- CSC policy:
  - Minimum/maximum traffic/computation load
  - Willingness to perform auto-scaling
- Policy enforcement and control:
  - Traffic inspection
  - SLA monitoring
  - Billing / accounting

Policy Enforcement

- Policy enforcement (PE) could be implemented via dedicated VNFs
  - May require transformation in the service graph of CSC provider
  - Additional complexity in CSC-aware slice placement



Policy Enforcement

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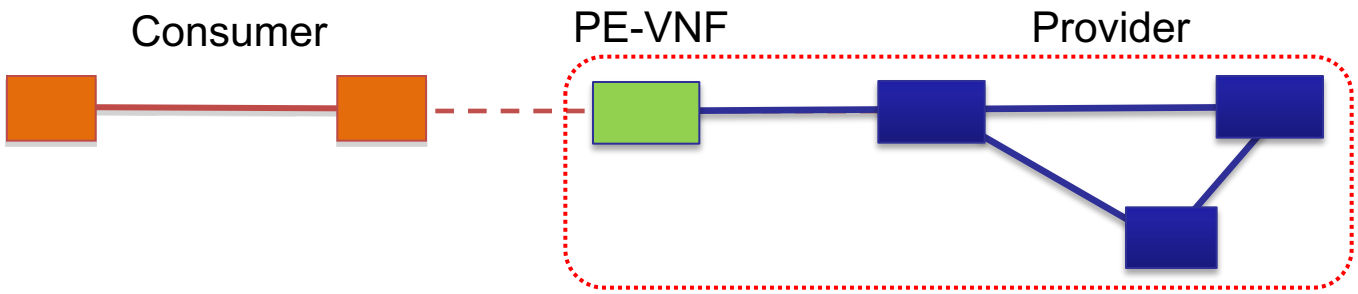
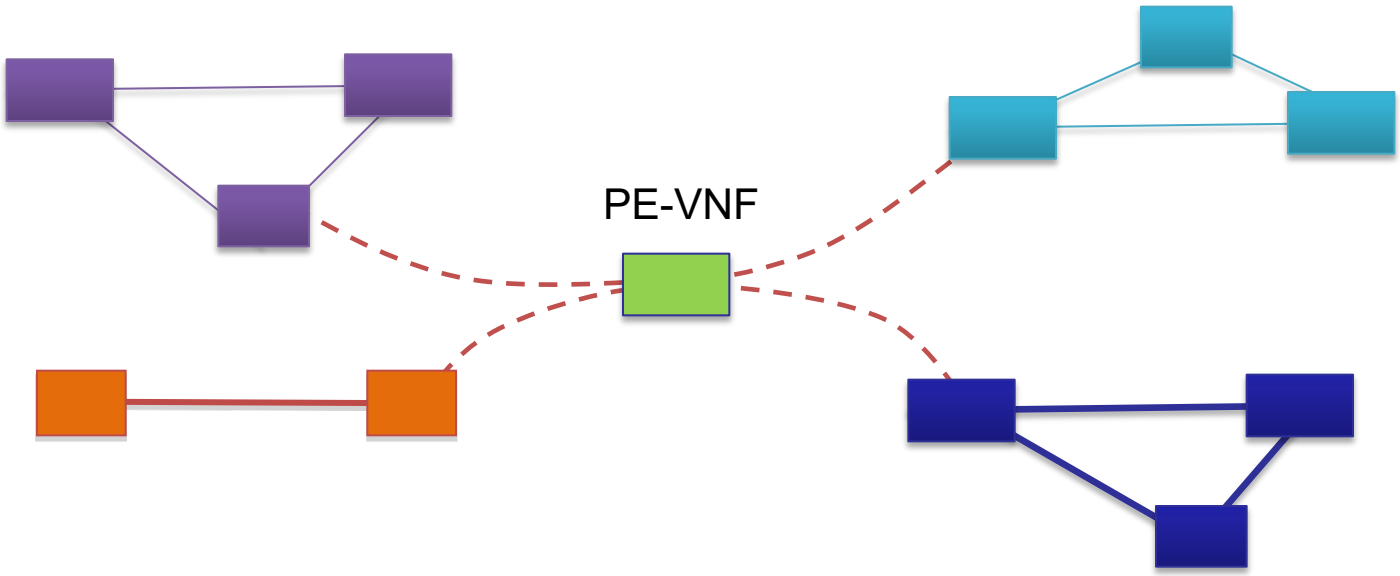
  - May require transformation in the service graph of CSC provider
  - Additional complexity in CSC-aware slice placement
  - Possible approach:
    - Integration of PE-VNF into the provider's service graph



Policy Enforcement

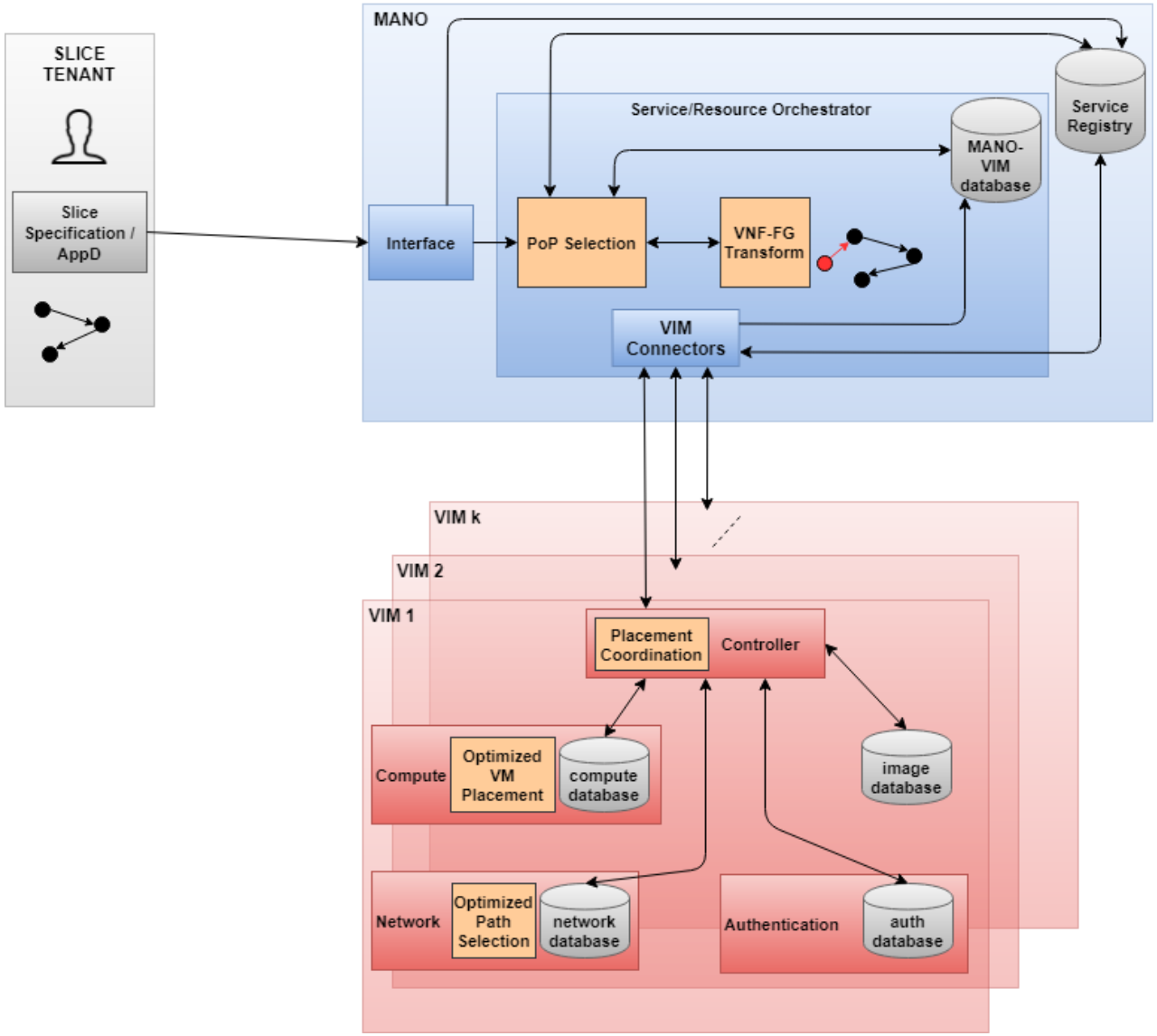
- Policy enforcement (PE) could be performed via shared VNFs:
  - Multiple CSC paths could traverse through a shared PE-VNF
  - PE-VNFs may comprise a service offered by the infrastructure provider
    - Analogy with IXP in ISP peering



Limitations in Policy Enforcement

- Traffic may be encapsulated (e.g., GTP)
  - Difficulty in traffic steering / inspection
    - Decapsulation/re-encapsulation within the edge cloud
    - New mechanisms that apply processing operations on encapsulated traffic

MANO Extensions for CSC



Conclusions

Conclusions

- Cross-slice communication opens up new opportunities for B2B synergies in edge computing:
  - Enhanced application performance (e.g., lower latency)
  - Reduced network traffic
- Need for CSC orchestration:
  - Service discovery
  - CSC-aware slice placement
  - Peering policies come into play
- Stay tuned for MESON orchestration platform!
  - http://meson-project.gr/

Thank you!

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